THE ARTICULATION OF SCHOOL AND COLLEGE WORK IN THE SCIENCES[1]

II

SCHOOL SCIENCE *in posse*

It is not difficult to enumerate some of the principles which should be kept in view in trying to render school courses in science more uniform. Those mentioned below are selected almost entirely on account of the benefit they would confer on the school. It would be a mistake to distort the natural work of the high school so as to fit it to the college course. The obligation lies on the other side. It should be added that no originality is claimed for these suggestions. They all arise from study of schools where the sciences are successfully taught.

1. All courses in the fundamental sciences—physics, chemistry, botany, and zoölogy—on the basis of which advancement in college is to be claimed, should include an adequate proportion of laboratory or field work by the pupils.

Introductory general science work, such as that given in the first year of the Chicago high schools to large classes of school freshmen, where admission credit is to be claimed but no advancement in college is expected, may possibly dispense with laboratory and field work, if limited accommodation and limited teaching force render this unavoidable. It would be of immense advantage to the pupils, however, in consideration of the start this would give them in the methods of thought and work in science, if no exception were made even here. Such work is possible, as has been shown in the Cleveland High School, the Lewis Institute, and elsewhere, and the expense is no valid objection if the necessity is proved.

2. The courses in each science should be not less than one year in length and should be of the same weight as courses in

[1] Expanded from a report presented to the N. E. A. in July 1898 (Report for 1898, p. 964), and a paper read before a joint meeting of the high school and college section of the Illinois Teachers' Association in December 1898.

other subjects. In view of the fact that home preparation is not required for laboratory work, double periods of time should be assigned to it. Thus, if the ordinary courses occupy four to five periods a week, the courses in science should comprise not less than two periods in the class room and four periods in the laboratory.

3. Each school should offer four complete years of work in science, although all of this will not be required of every graduate. If the resources of the school do not enable it to offer so much work in the sciences, while maintaining the highest quality in each course, a selection from among the sciences should be made and full, first-class courses in the sciences selected should be given. Economy should not be attempted at the expense of the quality of the work, nor should shorter or lighter courses in a larger number of sciences be preferred.

4. No science teacher should be asked to teach more than two or at most three sciences. In view of the fact that, for efficient teaching of science, preparation of apparatus and material for demonstrations and laboratory work are necessary, science teachers cannot be expected to carry more than half the number of recitations assigned to other teachers.

5. The school course in each science should be designed in the interest of the school pupil, without reference to whether the pupil is going to college afterwards or not.

6. Work in formal chemical analysis, and in detailed histology, or specialized work of any kind, is premature and out of place and proportion in a high-school course one year in length. Such work loses most of its value if unaccompanied by the broader knowledge which supplies the key to its meaning and unlocks the significance of each detail. In the school year there is not time for both.

The school work should confine itself to the elements of each subject, a careful selection of facts and full illustration of principles and modes of thought and work being given.

Any other plan will not only involve departures from the school ideal of a school course, but must inevitably lead to need-

less repetition in the college. A mixed school course is bound to infringe on, and partially appropriate the subject-matter of several different college courses and render any simple linking of school and college work impossible.

7. Unity in aim and similarity of content in the course in each science in all schools are indispensable if proper linkage with college work is to be achieved. This is being reached in other subjects: what is the objection to applying this principle to the sciences? There must be some course in each science on whose general outlines the college and the school can unite; a course which will fulfill the requirements of the school and whose approximate uniformity in all schools of the same class will supply the one condition of its acceptance by the college as a foundation for more advanced work in the same line.

8. The teacher should see that the material selected for the school course is thoroughly mastered by the pupils. It is often the case that a hazy impression of scientific modes of thought is all that the pupil carries away from his course in chemistry. College chemistry, my own included, seems to be as much affected by this tendency as school chemistry. The specific facts, inductions, and laws have been allowed to evaporate. One can no more build advanced chemistry on introductory chemistry of this kind than one can teach solid geometry to pupils whose plane geometry was equally ephemeral. It is needless to say that the benefit of changes in this direction would necessarily be felt by all the pupils whether they went to college or not.

It is not contended for a moment that school work in science disregards the above principles. On the contrary, it must be freely acknowledged that this work is rapidly improving, and that some approach to uniformity on lines like these is among the possibilities of the near future.

RECEPTION OF SCHOOL SCIENCE BY COLLEGES *in posse*

It has already been shown that few colleges have attempted either to define what they expect of the school, or to provide

suitable recognition of the school product when it is presented. The following propositions suggest a college policy:

1. All colleges and universities should recognize (1) the expansion and development which the teaching of the sciences in secondary schools is undergoing and (2) the value to their students, whatever their subsequent line of specialization, of an early introduction to science, by placing the sciences among their entrance subjects as requirements or options. One is inclined to say that physics should be required of every entrant, although dogmatism on this point may be premature. The other sciences should receive due credit among the admission requirements of certain courses.

2. Each college should study the work in the various sciences which is, or can be done in the schools tributary to it. It should then outline definitely what it expects by way of preparation in each science, when that science is offered at all. Finally, it should insist on the presentation of a kind and amount of matter substantially equivalent to this requirement whenever credit is to be given.

3. The college should grant advancement in the series of its courses in each science to an extent corresponding to the admission credit given. In other words, it must recognize adequately, and in a practical form, the extent to which the school work may fairly claim to constitute an anticipation of its own.

To effect this, each department in the college must adapt its own courses so that one of them shall offer a suitable continuation of the preparatory work. This will be open to those students who enter with a credit in the subject, and such students should never be required to begin the science over again in the same class with those who lack this credit and preparation.

To sum up, the college should provide for (1) entrance credit; (2) clear definition of preparatory work; (3) articulation with a suitable college course.

The last condition, although it is logically demanded by the other two, is harder to meet in the sciences than in other subjects, and requires separate discussion.

METHODS OF GRANTING ADVANCEMENT ON THE BASIS OF PARTIAL ANTICIPATION OF COLLEGE COURSES IN SCHOOL

The proportion of the college work in any science which the pupil from the school may be held to have anticipated, will depend on the relative weights of the school and college courses. A year's work in a school may be considered equivalent to about six months' work in college, where both courses occupy the same number of periods per week and the subject is taught with equal efficiency in both. This discount, which, we shall find, is already in force in connection with mathematics, will approximately offset the more rigid selection of the college students, the smaller size of college classes, the greater maturity of the constituents of these classes, and the greater volume of work which can consequently be demanded of them. Additional justification of this discount will be given later.

The impression appears to exist that there is only one possible way of granting the advancement earned. It is true that only one is in general use. This is

THE END-TO-END METHOD OF ARTICULATION USED FOR LANGUAGES AND MATHEMATICS

The college offers courses in these studies which are designed as sequels to various high-school units of work and follow each other in definite order. Thus, in French, one pupil begins the study in college and takes, in the first place, elementary work equivalent to a one year course in a preparatory school. This is followed, if he chooses, by work of a more advanced character. The pupil from the school, who receives credit for one year's French on entrance, is held to have anticipated the first college course, and enters the advanced course directly.

The amount of anticipation in mathematics is even more easily taken account of, for elementary algebra, plane geometry, solid geometry, trigonometry, advanced algebra, and analytics are fairly well-defined topics, and the pupil begins in college where he left off in school.

The adjustment in standard is often achieved in languages by giving a smaller number of hours per week to the college

introductory course than is allotted to the equivalent high-school course. In mathematics, so far as there is overlapping of the last three topics, the school takes half a year to each, while the college can dispose of them in three months. This scheme of discounting ("one third off") the time in school, in comparing it with time in college, seems to express a fair estimate of the average disparity between school and college courses.

These arrangements work well with subjects which are easily subdivided, or where the question is that of placing a college student who has had two, three, or four years of school work in each subject or group of subjects.

The problem is much more difficult when we consider the sciences. Not only so, but it seems to have received almost no consideration. No general method of articulation has been worked out and adopted so far. It has been shown above that, in the case of chemistry, three institutions only out of fifty-six possess any definite plan, and each has adopted a different one.

DIFFICULTIES IN THE WAY OF ARTICULATION IN THE SCIENCES

There are two classes of difficulties to be overcome. One of these lies in the present want of uniformity in the science work in different schools. This is a mechanical impediment and can be removed. There is no reason, inherent in the subjects themselves, why the work in each science in different schools should not be assimilated to the same extent as in mathematics. Even if this were accomplished, however, would the method of articulation in use for mathematics prove applicable in the case of science? Two reasons may be selected to justify the conclusion that this would not remove the most serious difficulties and that simple end-to-end articulation with regular college courses, in the case of some of the sciences, would still be out of the question.

In the first place, the difference in age and surroundings of the pupils, while it leads to some disparity between school and college French or geometry, entails a much greater divergence of standards in the sciences. Science deals with a less closely restricted range of premises, and a less strictly confined set of possible conclusions than geometry, and it cannot be represented

graphically with so much simplicity. It benefits less from the faculties strongest in childhood, like imitativeness and memory, than French. It depends more than these on seeing things in their relations, and therefore gains much from greater maturity in its students.

In the second place, under our present curricula, a year of school language work gives more knowledge of a particular language than a year of school chemistry gives of chemistry. A year of French, for example, is not simply this. It is a part of a long training in the study of language. The general scheme of such study is already a part of the pupil's habit of thought. It will, therefore, be a full measure of French as a specific branch of study. Similarly, a course in quadratic equations will be all devoted to this special topic, since the machinery of mathematical thought has already been acquired. On the other hand, the pupil preparing for college often takes but one year of science. This year, it may be of physics or chemistry, is often isolated. The work is of a novel kind. The proper mental attitude toward science in general has to be developed. The use of a laboratory has to be learned. The pupil sees and handles for himself, and the most valuable acquisition he makes is the discovery that the facts of the science are as well within his own reach as if the writer of his text-book had never existed. But the power to study and interpret the subject-matter of the science for himself is not acquired by him all at once. Much of the time is spent on what is practically an introduction to the methods of finding and dealing with data scientifically. The progress in physics or chemistry, as specific studies, will be less than it would have been in French or mathematics, if the time had been assigned to these instead.

The discrepancy is increased by the fact that not only has a new attitude of mind to be cultivated, but a long established one has to be overcome. The habits of thought already developed are largely antagonistic to those to be acquired, and the teacher of a science often meets with a positive resistance to his efforts to direct the mind of the pupil. The previous work has almost inevitably led the pupil to trust to other people

for his facts, and to authority for his opinions. It is hardly possible for elementary language work to develop any other frame of mind, however strenuously the teacher may try to obviate the tendency. This bias has to be removed before progress in physics or chemistry, as such, can begin.

If the case were reversed, and an almost completely isolated year of French were in question, it is evident that the value of the work would be less specifically, as French, in proportion as its rôle had been more that of an introduction to language study in general.

These two are among the reasons which lead one to doubt whether a claim to anticipation of the same amount of college work could be founded on a year in school in a science, even if it were a known quantity, as on a year in French or Latin.

Even if, in spite of these considerations, school work in science is subjected to no greater discount than that imposed in the case of mathematics (one third), the nature of the college courses, alongside of which the anticipation is to be measured, will usually frustrate the desire to arrange an articulation like that used for mathematics. For the same reasons which prescribe a year as the minimum length for a school course in each science are equally decisive in fixing a similar length for the college courses. Even in college, the majority of the students are comparatively inexperienced in the study of science. A year is necessary if manipulative and observational skill are to be acquired, or if any permanent impression is to be made on the students' habits of thought. A shorter course might give information about the science, but the actual changes in the brain which a proper introduction to science implies can be obtained only by long contact with one or two sciences. If the first year of physics or chemistry in college, therefore, is a homogeneous course, it is very evident that a school pupil, with a total knowledge of the subject equivalent to six months of college work, is nevertheless a complete misfit if he enters at the beginning of the seventh month. He has anticipated a part of the remaining three months' work, and yet he lacks a part, and probably an important part, of the preparation for it which the college

students have received. In the biological group subdivision of the college course, so as to leave a well-rounded section of each subject to the school, seems to be more easily accomplished than in the physical group.

The result of all these circumstances is that the pupil, after a preparatory school course in chemistry, is seldom ready to undertake work in analysis or organic chemistry. After preparatory physics, he is seldom ready to enter a course in mathematical or advanced experimental physics. Even after school botany or zoölogy, he is not always ready directly to pass into more advanced branches of biological work. It is difficult, if not impossible, for a school to anticipate the whole of a thorough introductory college course in a science.

The college necessarily gives a heavier course in a year than the school. The course is fuller and more advanced by a half. The problem is to provide some means of granting advancement corresponding to the partial anticipation of this course which has been accomplished. Four methods are conceivable, and all four are in use.

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(To be concluded)